



Observations of the Axisymmetric Tropical Cyclone Diurnal Pulse using Synthetic Observations from the TROPICS NASA Earth Venture Mission

Erika L. Duran, University of Alabama in Huntsville/NASA Short-term Prediction and Research Transition (SPoRT) Center

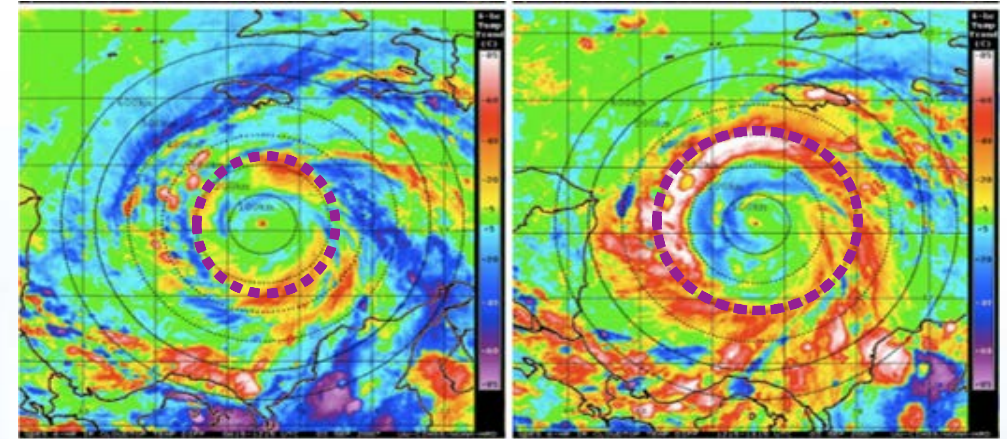
Emily Berndt, NASA Marshall Space Flight Center/NASA SPoRT

National Weather Association Annual Meeting, Huntsville, AL

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- Observations reveal a coherent tropical cyclone (TC) diurnal cycle (TCDC) that manifests throughout the TC environment.
 - Daily oscillations are seen in cloud-top temperature (e.g., Dunion et al. 2014) and precipitation (e.g., Leppert and Cecil 2016).
 - Also linked to TC convection via outward propagating squall line features (Dunion et al. 2014)
- **Current polar-orbiting observing systems and the passive microwave constellation lack the ability to fully resolve the TCDC**
 - Even with the increased temporal resolution of the GOES-R series, high viewing angles and gaps in geostationary field of views can cause issues
 - Makes observational analysis challenging

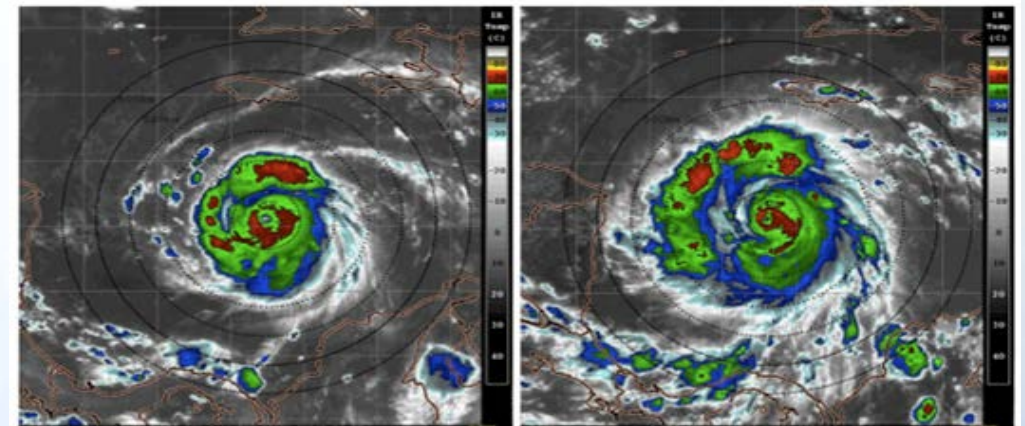
6h Differences in Brightness Temperature



07:15 LT

18:15 LT

Infrared Brightness Temperature



07:15 LT

18:15 LT



TROPICS Mission Overview



- **Earth Venture Instrument to measure TC structure**
- **Design**
 - 6 CubeSats with 12-channel passive microwave radiometer (MicroMAS-2) measuring frequencies between 91 and 205 GHz
 - Provide rapid-refresh observations of temperature and moisture soundings and precipitation over the tropics with <60 minute revisit time
 - Meet requirements for temporal refresh needed to study storm evolution with ability to see into clouds
- **Rapid-update observations provide the opportunity to observe the full evolution of the TCDC**
 - Can sample multiple radial locations from the storm center at different times of the day to track TCDC evolution



TROPICS = Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats

<https://tropics.ll.mit.edu>

- **Goal:** Since TROPICS is not anticipated until early 2021, use proxy data to test the ability of TROPICS to resolve TCDC prior to launch
 - Utilize atmospheric soundings to analyze the thermodynamic environment of the TCDC
- Current TROPICS proxy data only includes brightness temperatures (i.e., L1 products)
 - Sounding analysis requires synthetic L2 products

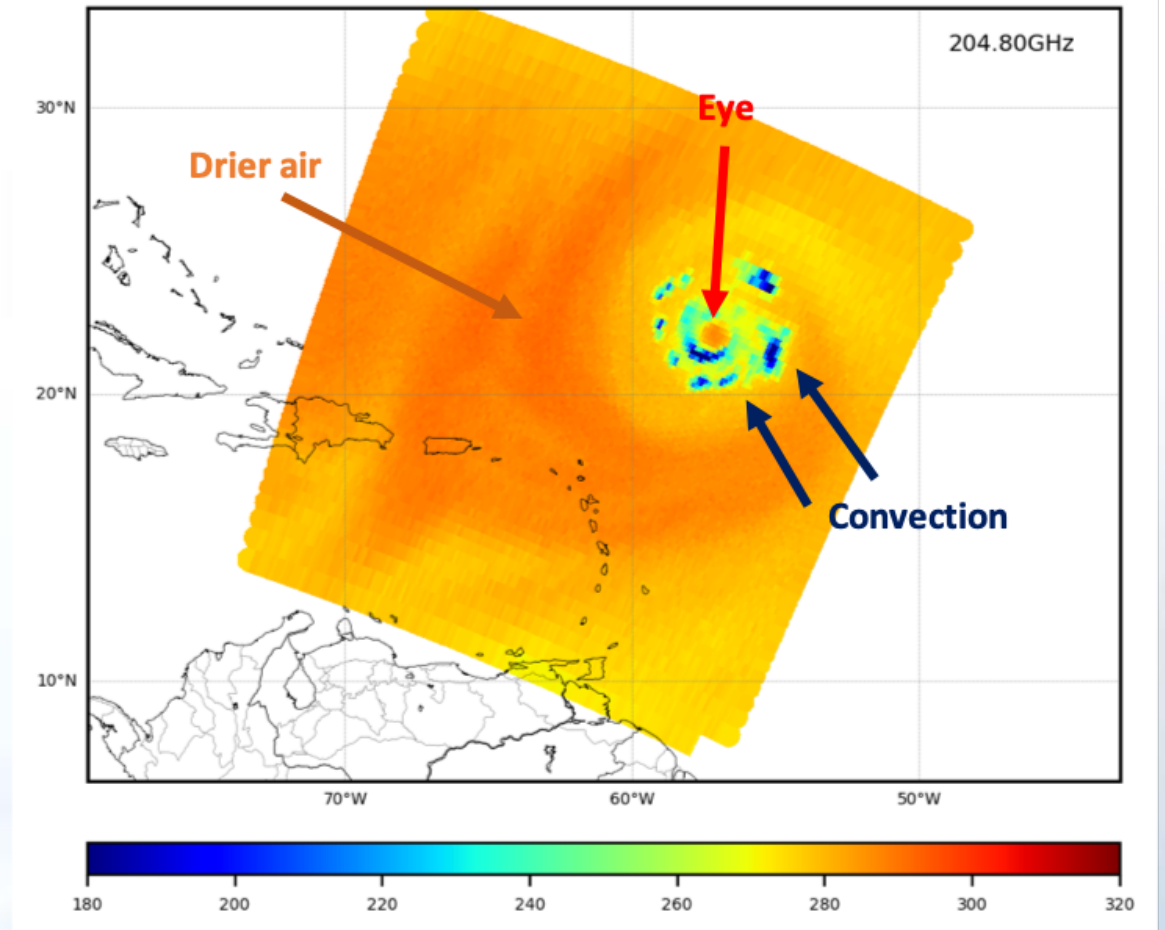
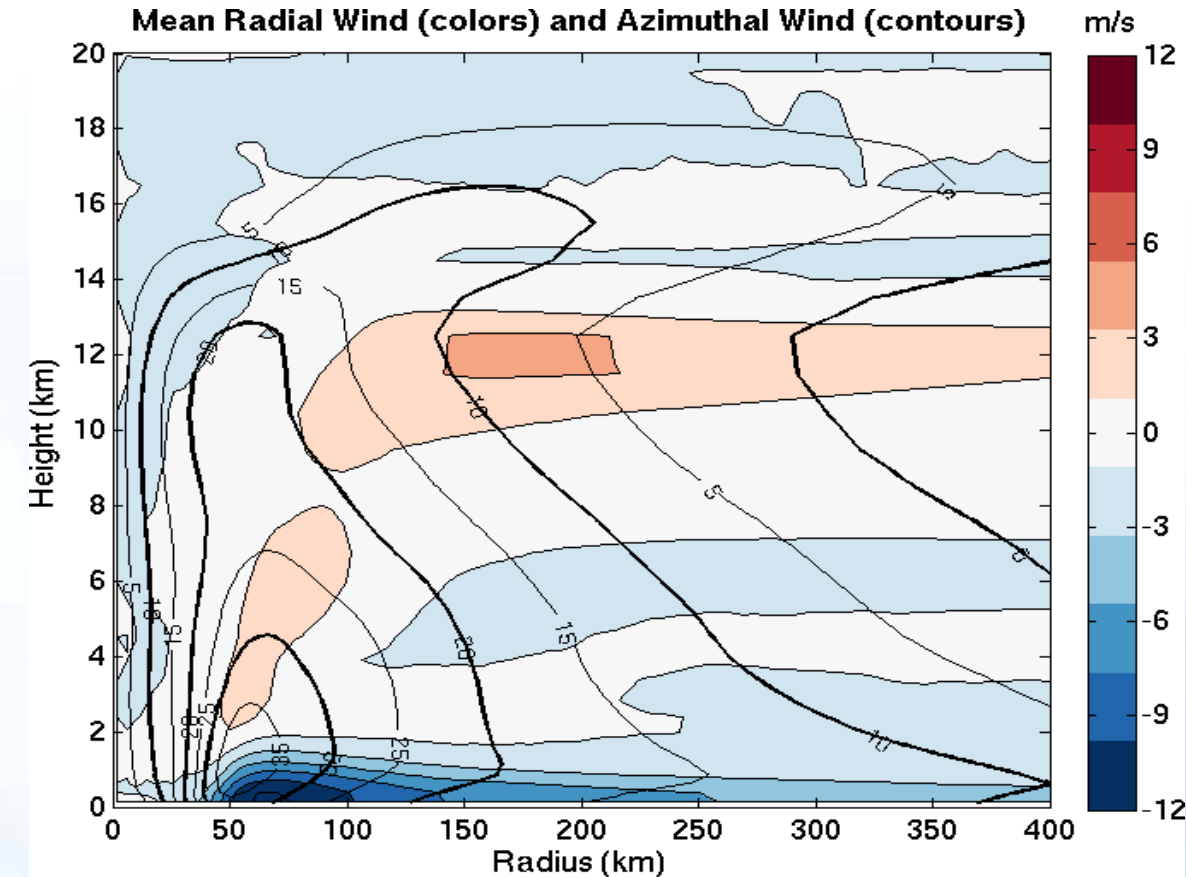


Image courtesy of Frank Lafontaine,
Jacobs ESSCA/NASA SPoRT

- Create synthetic L2 TROPICS observations using 2D, idealized simulation of Navarro and Hakim (2016)
 - Steady-state TC produced in Cloud Model 1 (CM1) version 15 (Bryan and Rotunno 2009)
 - Axisymmetric simulation with no external influences (e.g., land, shear, etc.)
 - 300 days of a mature TC
- Caveat: output is hourly, so actual TROPICS resolution will be ~40 min



Navarro and Hakim (2016)



Synthetic L2b Data Products



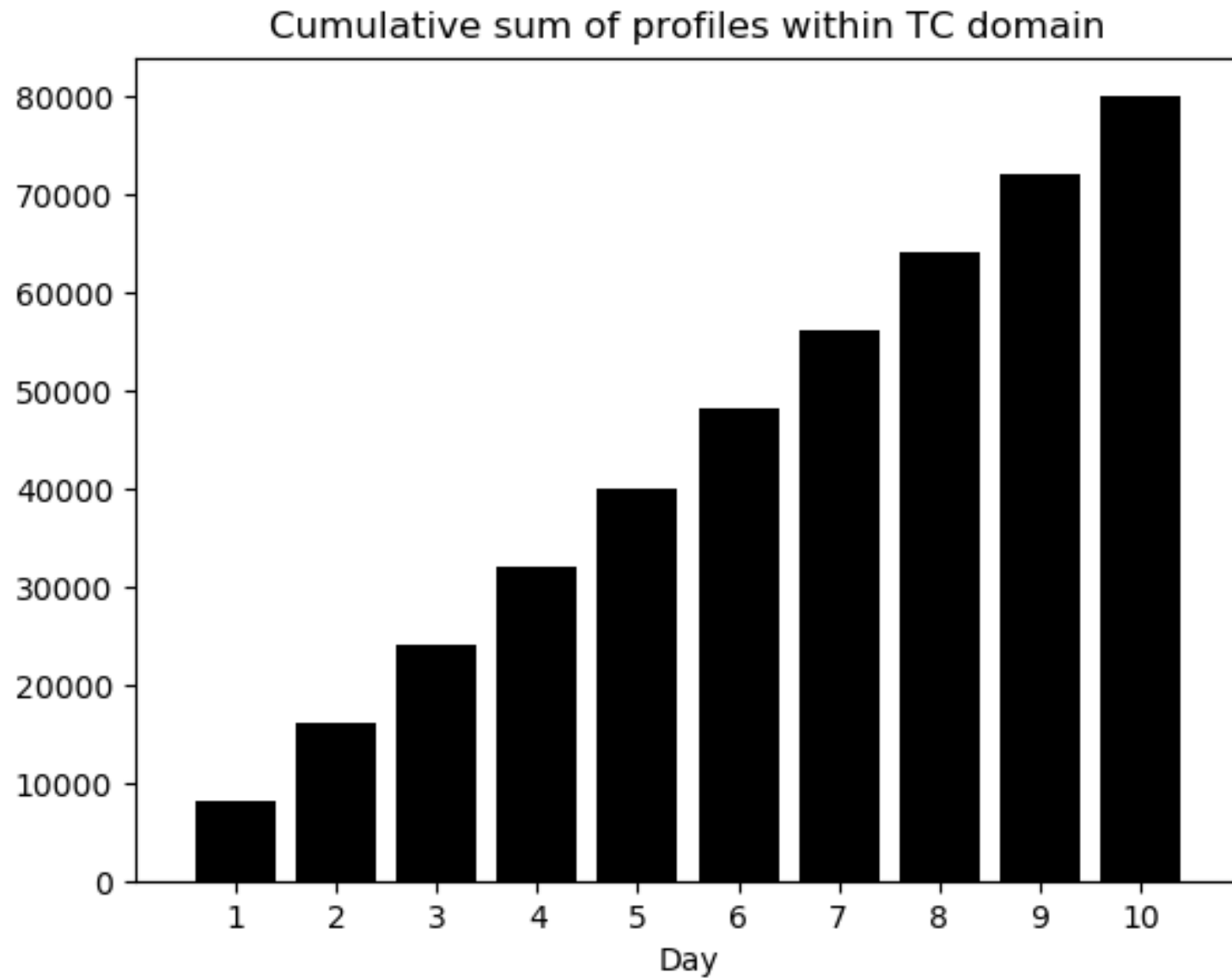
- Simulate satellite overpasses using a 30-day orbital simulation of the baseline mission
 - Repeat every 30 days to match duration of model output
 - Spatially blur CM1 spatial resolution to estimates from TROPICS

L2 Product	Resolution	Uncertainty
Vertical temperature profile (K)	50 km scan-averaged	2 K r.m.s
Vertical moisture profile (g g^{-1})	25 km scan-averaged	25%
Instantaneous Rain Rate (mm h^{-1})	2.5 x 2.5 degrees	25%
TC intensity: minimum sea-level pressure (hPa)		10 hPa r.m.s
TC intensity: maximum sustained wind (m s^{-1})		6 m s^{-1} r.m.s

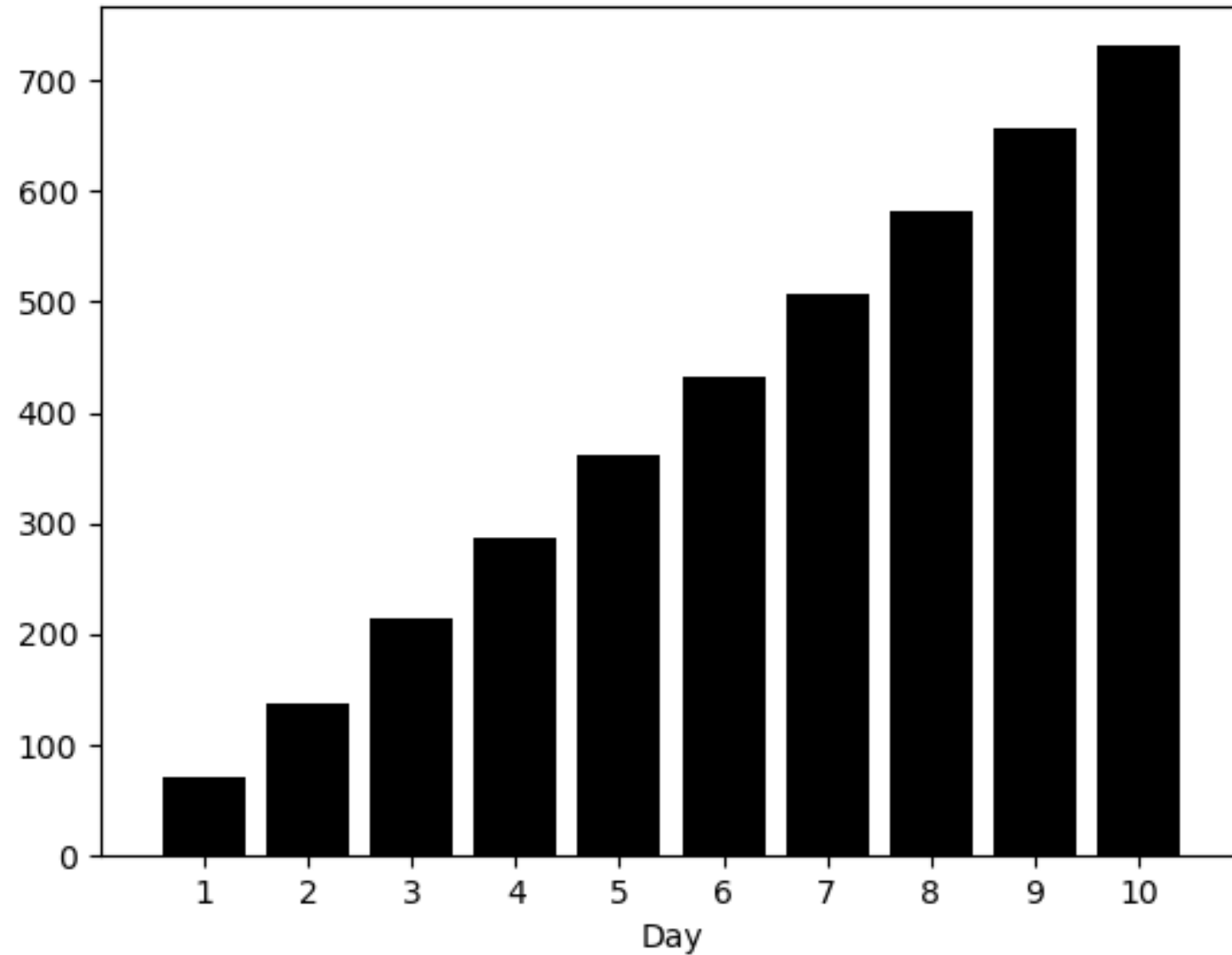
Blackwell et al. 2018



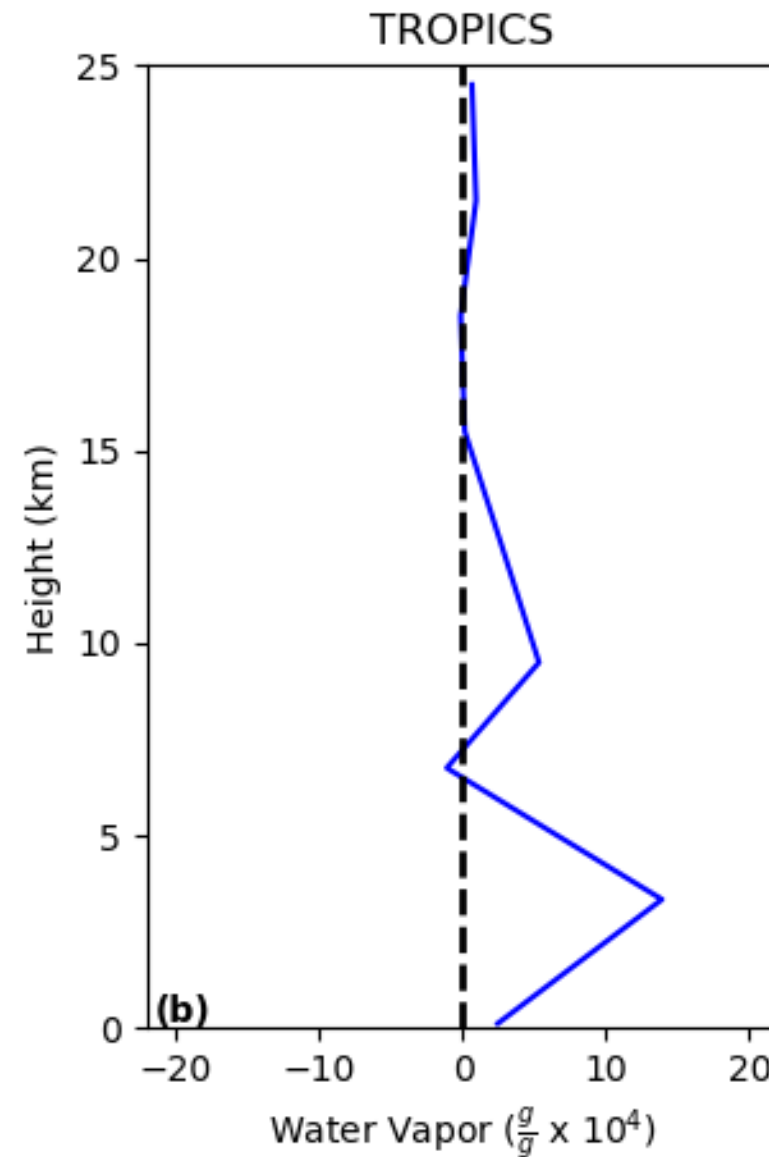
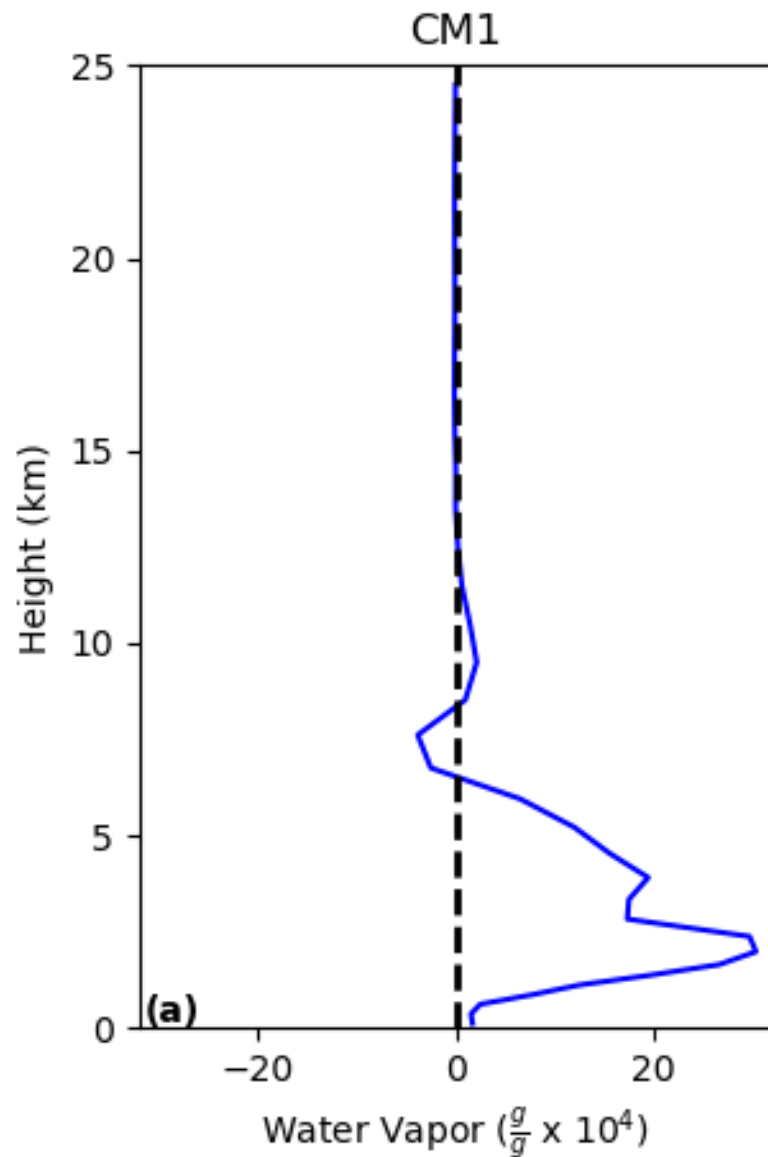
TROPICS Orbital Simulation



Cumulative sum of profiles at 50 km

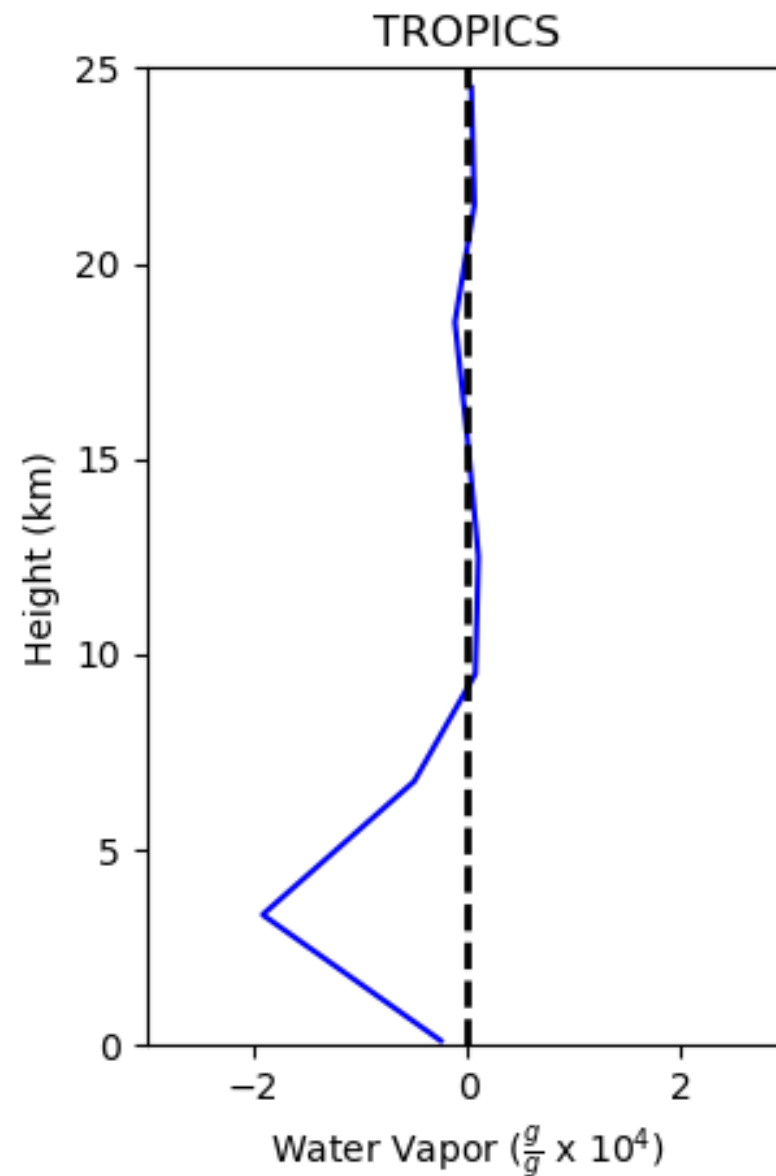
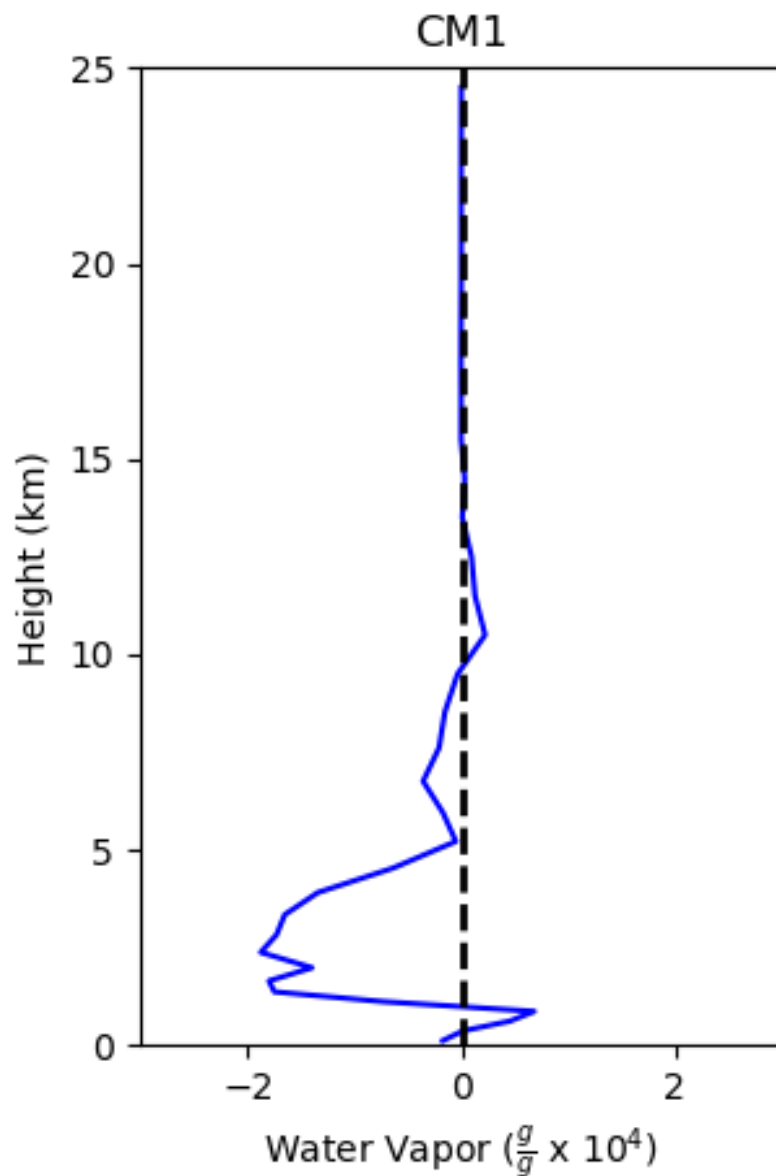


Model vs. Synthetic Moisture Profile



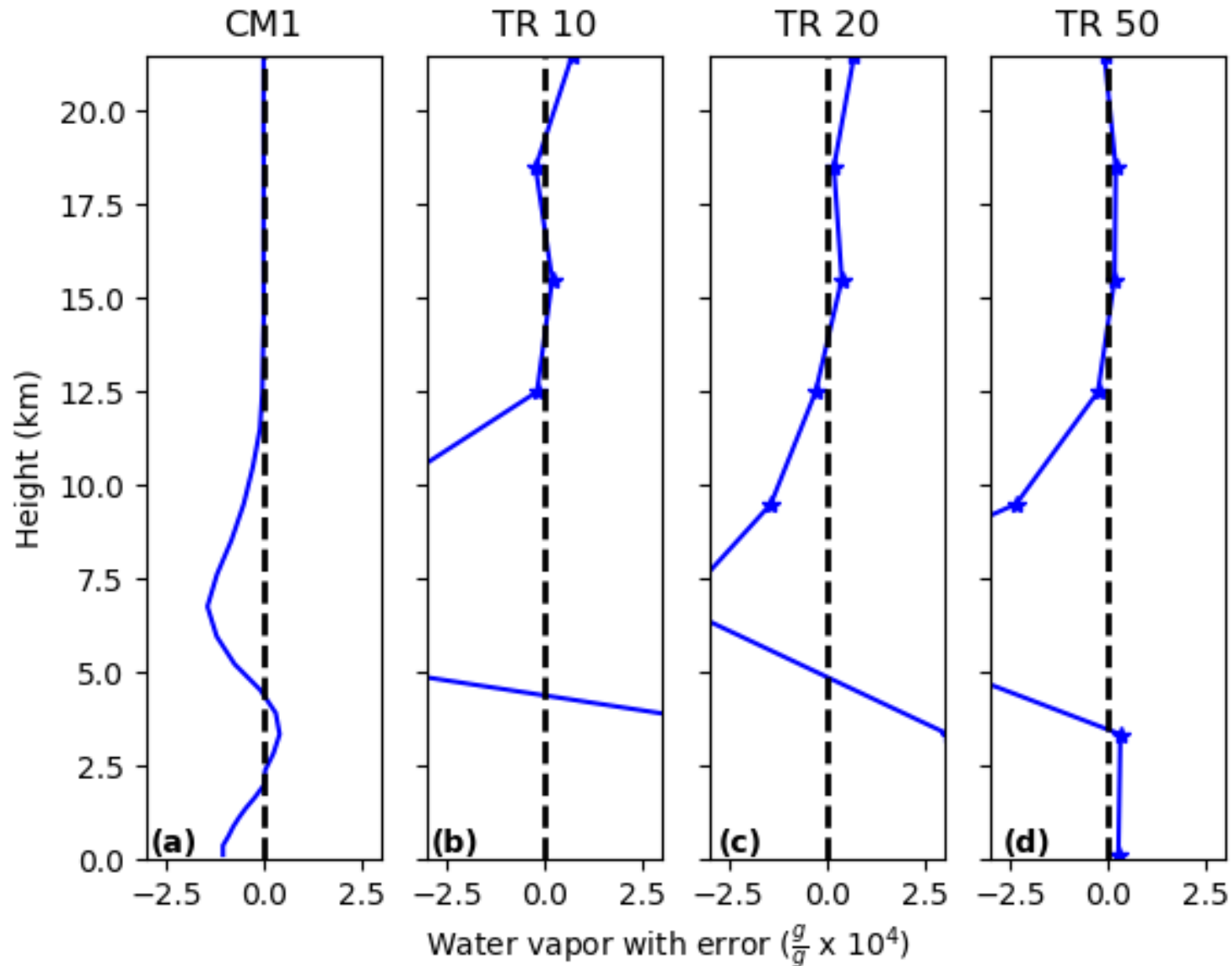
TROPICS
simulates overall
shape of profile

Model vs. Synthetic Data Composite Profiles



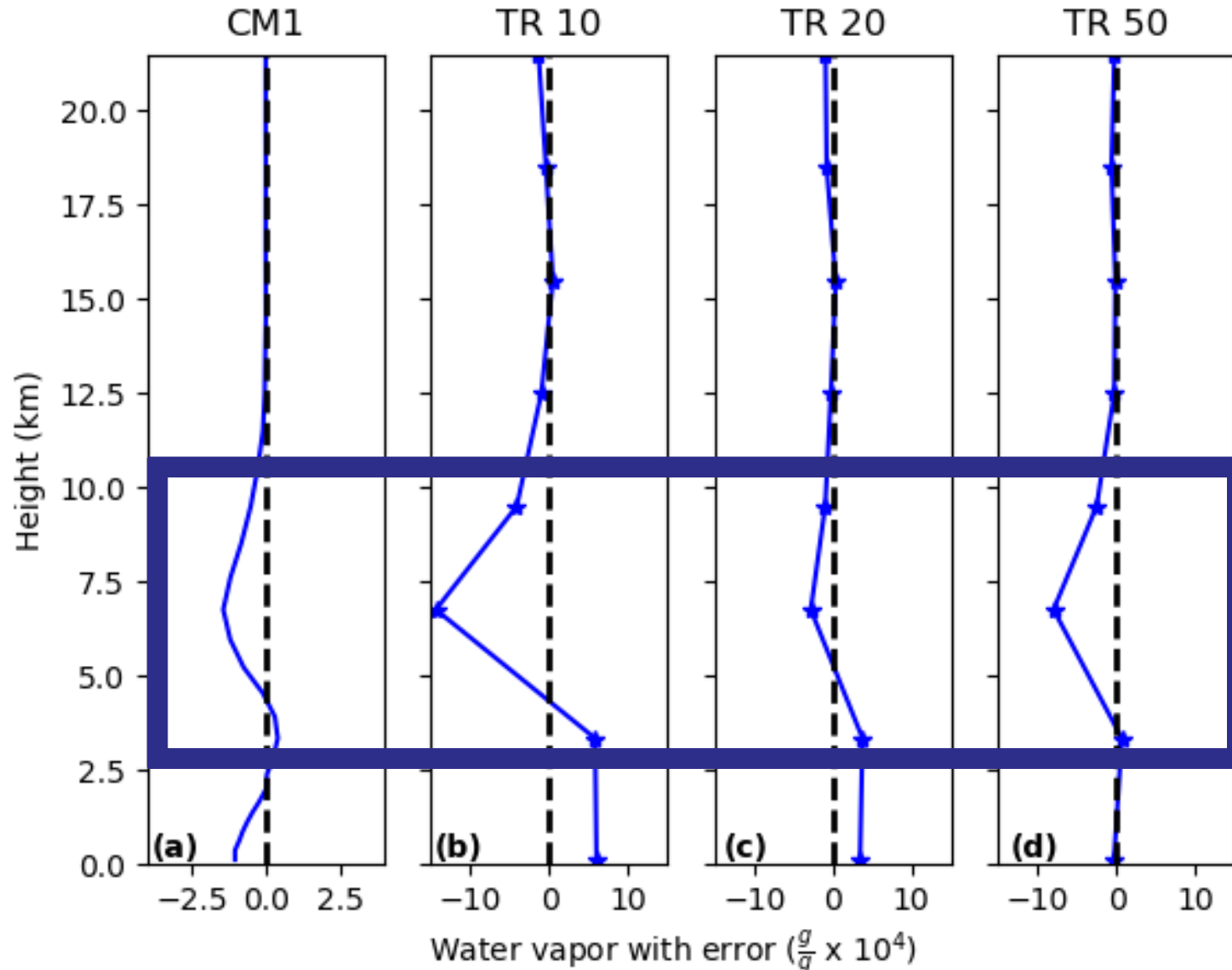
Composites of
TROPICS
profiles simulate
both shape and
magnitude

TCDC Anomalies at $r = 50$ km and 00 LT



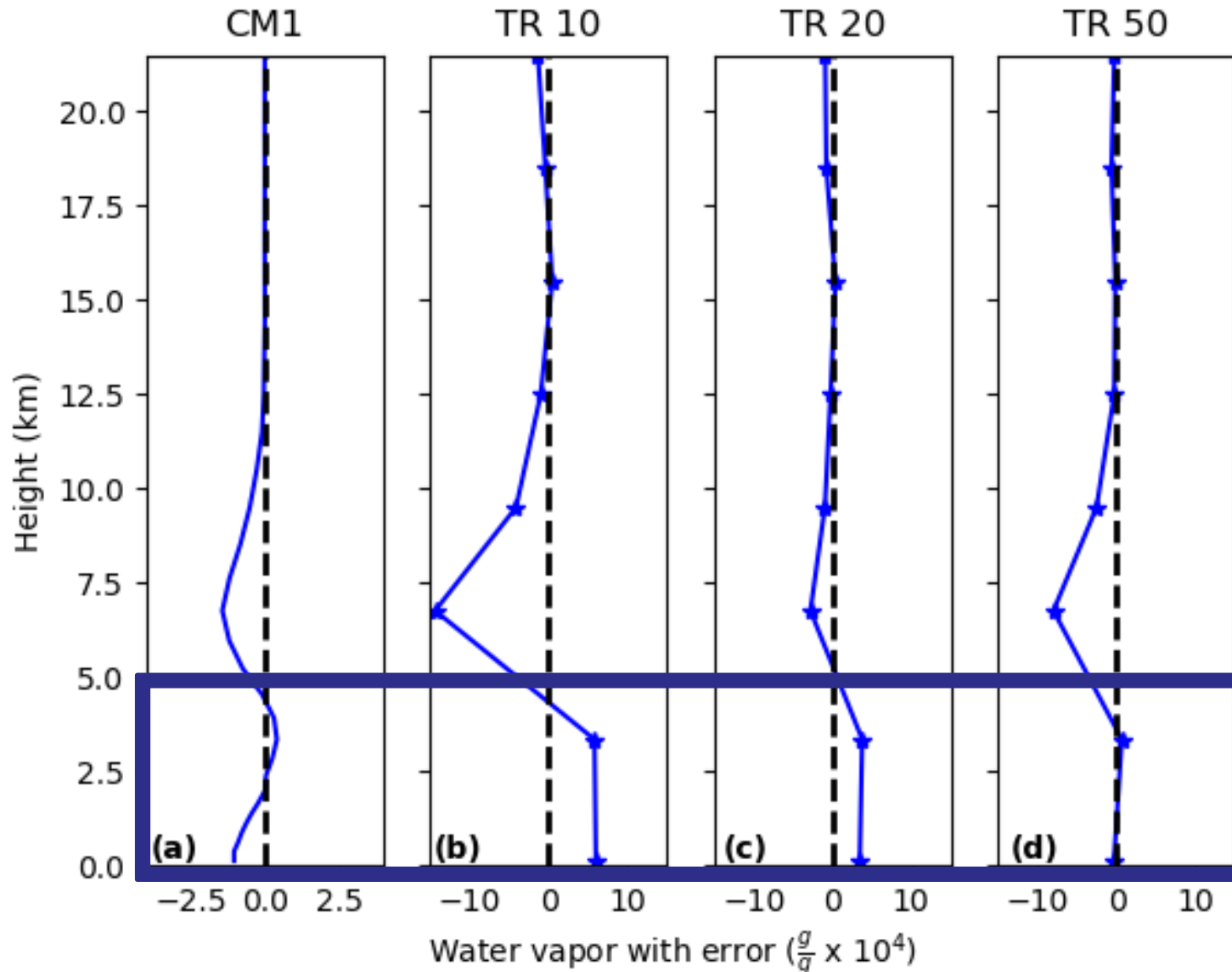


TCDC Anomalies at $r = 50$ km and 00 LT



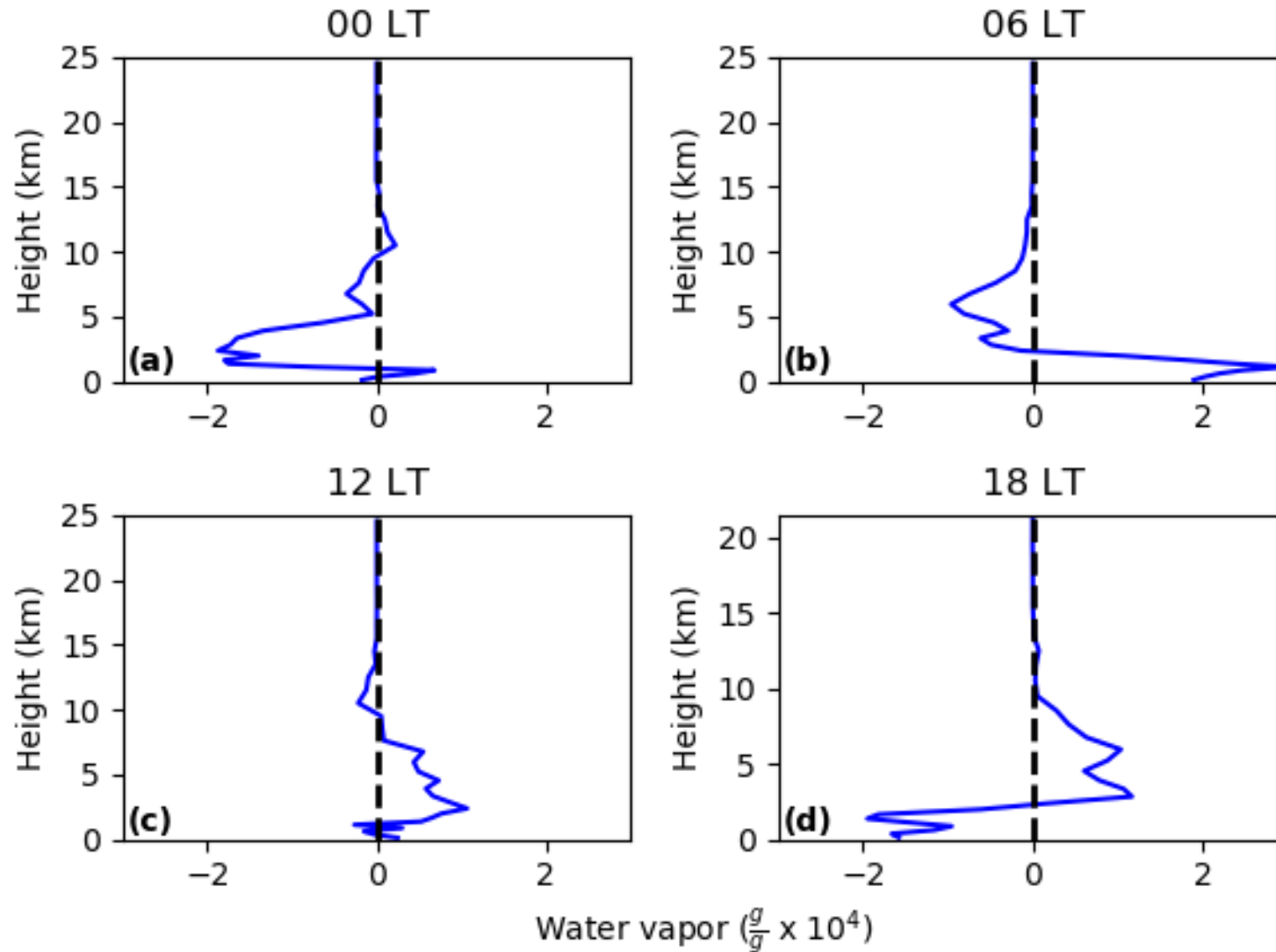
Larger
composites of
TROPICS
profiles provide
better estimates
in magnitude

TCDC Anomalies at $r = 50$ km and 00 LT



Lower levels
more difficult to
observe

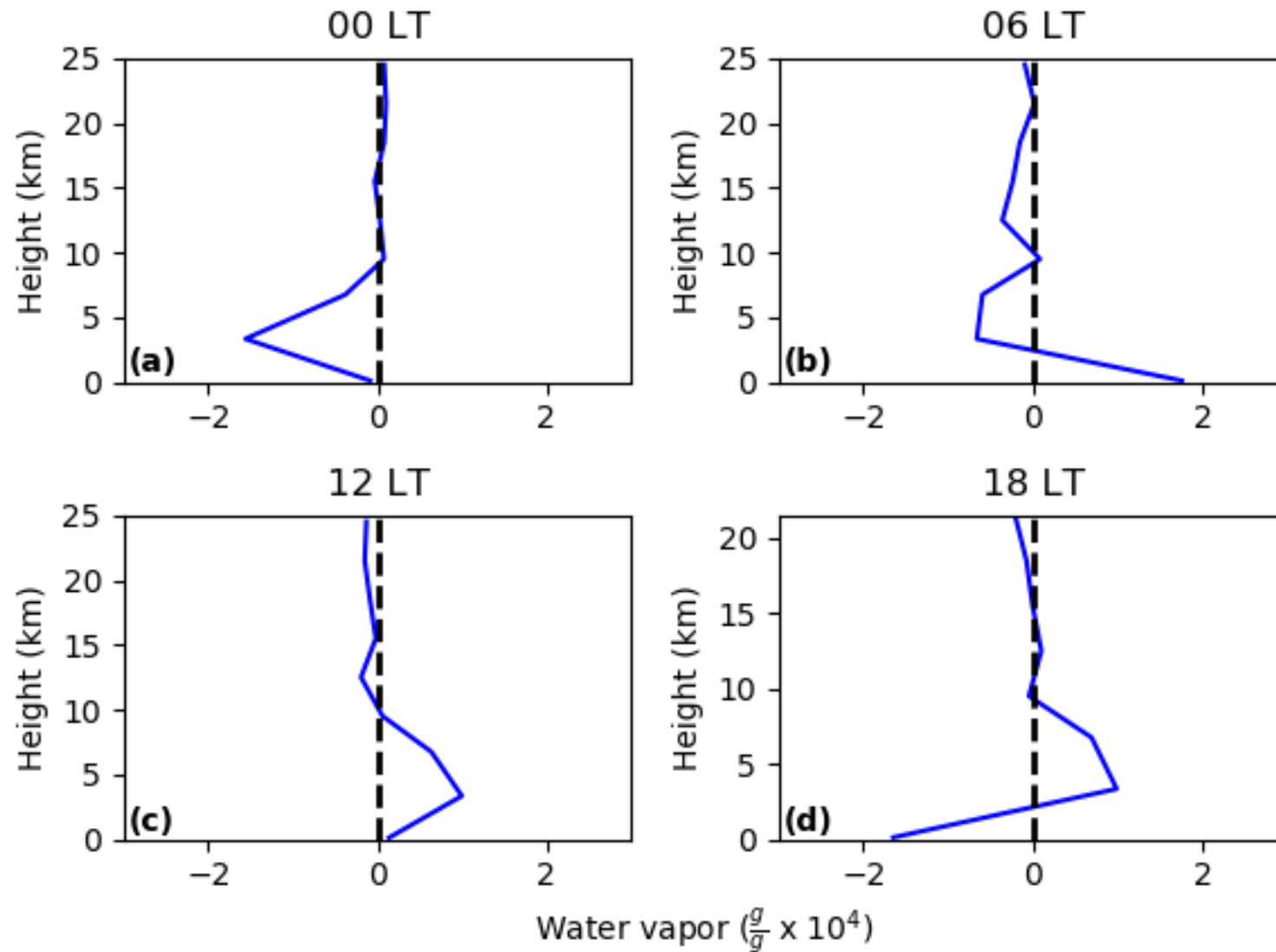
Model TCDC Moisture Evolution



Moistening
between ~2-8 km
throughout the
day; drying from
5-10 km
overnight



TROPICS TCDC Moisture Evolution



TROPICS
simulates overall
sign and shape
of profile



Summary (1/2)



- NASA TROPICS mission provides a unique opportunity to observe the full evolution of the TCDC
- Using synthetic L2 data products, TROPICS shows promise in resolving anomalies that arise from TCDC
 - motivates continued analysis of the TCDC using TROPICS, as well as other applications of the mission



More Information (2/2)



- As an official early adopter of TROPICS, NASA SPoRT is currently assessing the capabilities and applications of the upcoming TROPICS mission
 - <https://tropics.ll.mit.edu>
- Contact:
 - Erika: erika.l.duran@nasa.gov (Twitter: ErikaL_Navarro)
 - Emily: emily.b.berndt@nasa.gov (Deputy Applications Lead)

Please contact us with questions or for more information!

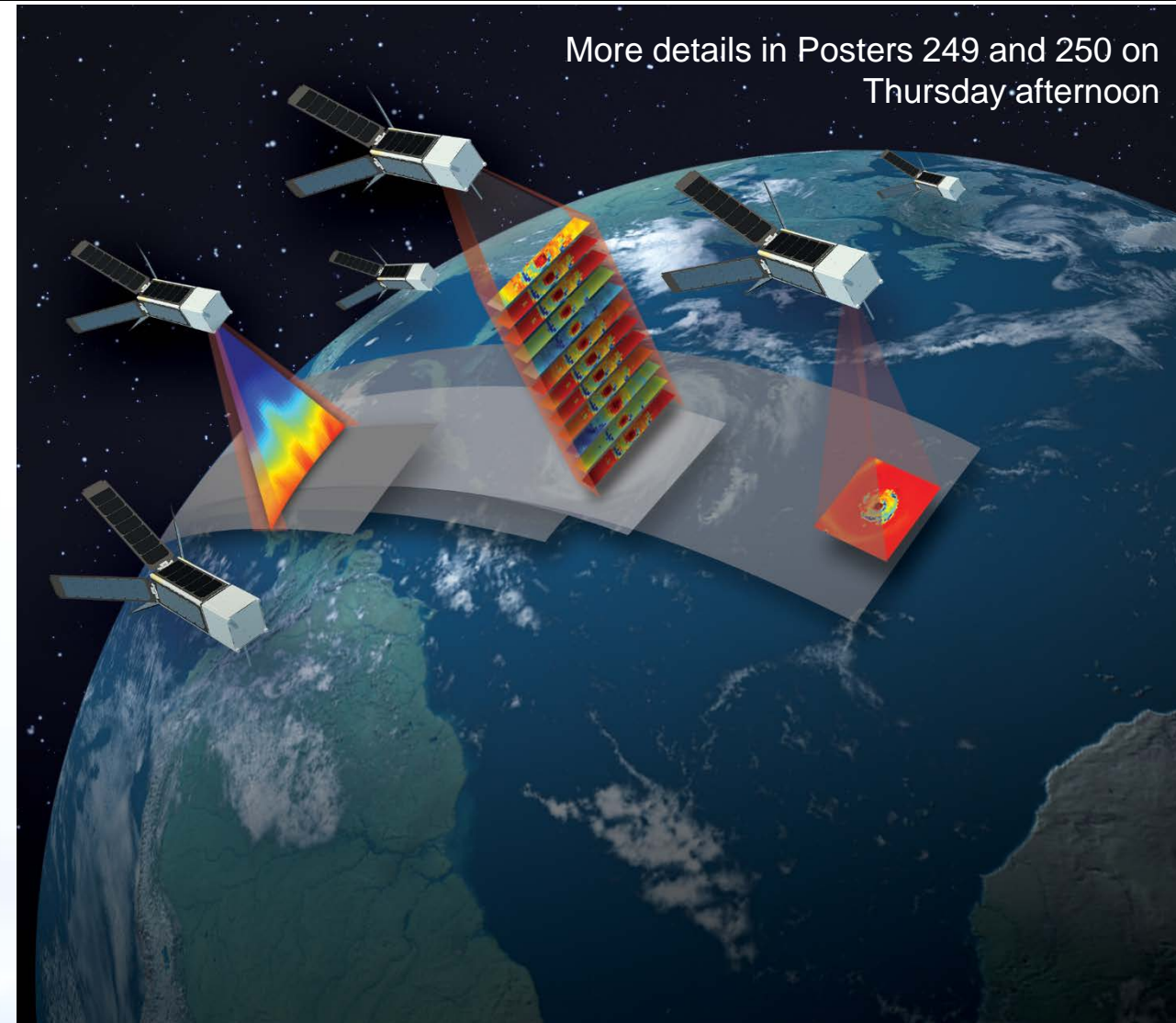


Thank you!

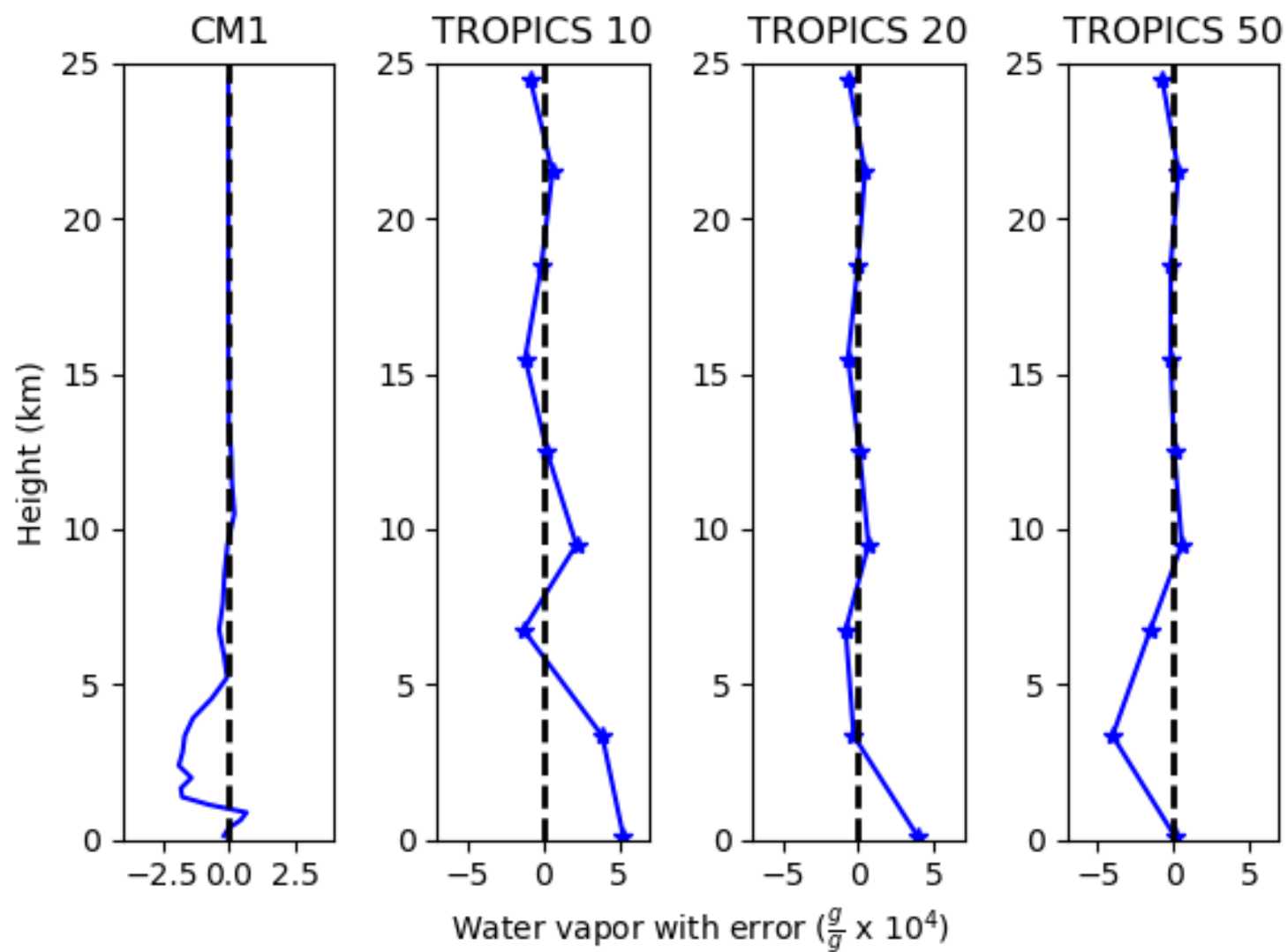


- **Science objectives**

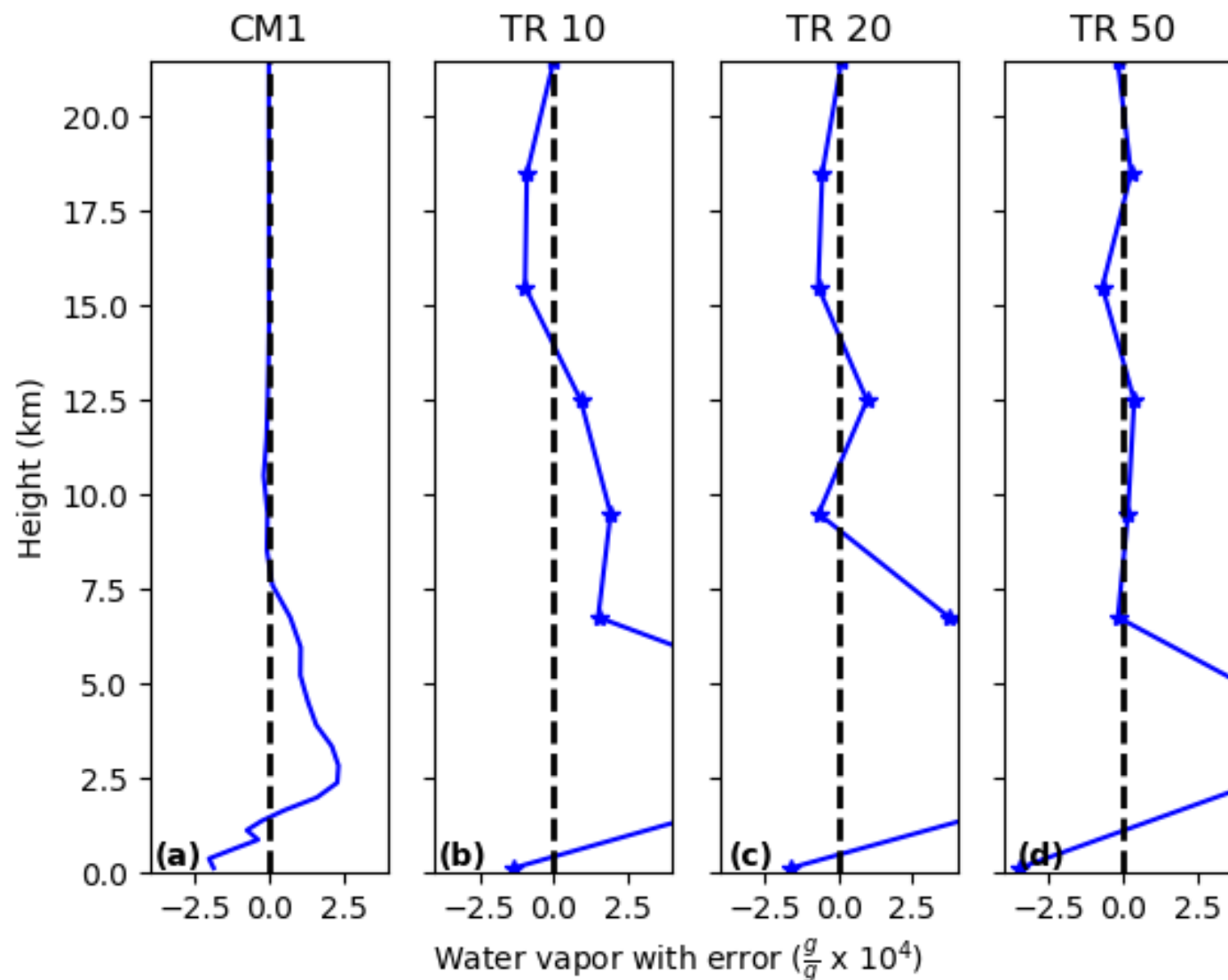
- Relate precipitation structure evolution, including diurnal cycle, to the evolution of the upper-level warm core and associated intensity changes
- Relate the occurrence of intense precipitation cores (convective bursts) to storm intensity evolution
- Relate retrieved environmental moisture measurements to coincident measures of storm structure (including size) and intensity
- Assimilate microwave observations in mesoscale and global numerical weather prediction models to assess impacts on storm track and intensity



TROPICS = Time-Resolved Observations of Precipitation structure and storm Intensity with a Constellation of Smallsats

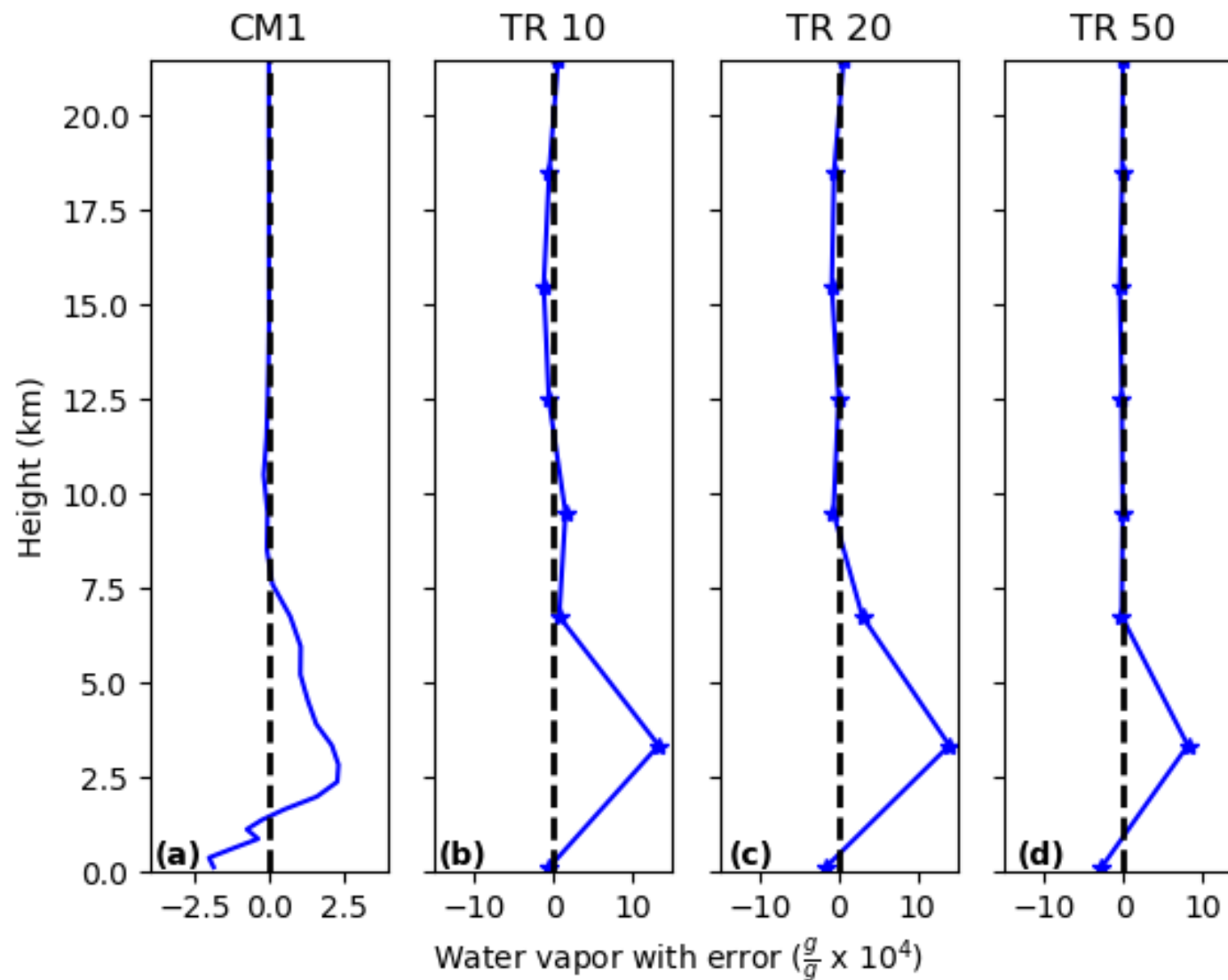


TC Diurnal Cycle Anomalies at $r = 218$ km and 00 LT



TCDC
at this radial
location

TC Diurnal Cycle Anomalies at $r = 218$ km and 00 LT



TCDC
at this radial
location